STRUCTURAL DESIGN – I

8. RELEVANT PROVISIONS OF IS456-2000

KIRAN S R

Lecturer

Department of Civil Engineering

Central Polytechnic College Trivandrum

ENVIRONMENTAL EXPOSURE CONDITIONS

Table 3 of IS456 (Page 18)

Table 3 Environmental Exposure Conditions

(*Clauses* 8.2.2.1 *and* 35.3.2)

Sl No.	Environment	Exposure Conditions
(1)	(2)	(3)
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet
		Concrete exposed to condensation and rain
		Concrete continuously under water
		Concrete in contact or buried under non-aggressive soil/ground water
		Concrete surfaces sheltered from saturated salt air in coastal area
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
		Concrete completely immersed in sea water
		Concrete exposed to coastal environment
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet
		Concrete in contact with or buried under aggressive sub-soil/ground water
v)	Extreme	Surface of members in tidal zone
		Members in direct contact with liquid/ solid aggressive chemicals

REQUIREMENTS BASED ON EXPOSURE CN.

Table 5 of IS456 (Page 20)

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 *and* 9.1.2*)*

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

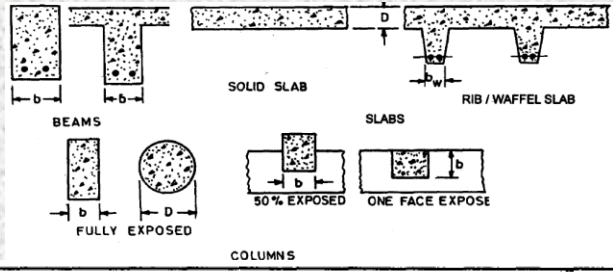
1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in **5.2**. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

MINIMUM DIMENSIONS OF MEMBERS

Cl.21 and Figure 1 of IS456 (Page 33,34)

Structural elements should be designed to possess an appropriate degree of ***resistance to flame penetration, heat transmission and failure***. The fire resistance of a structural element is expressed in terms of time in **hours**.



Fire Resistance h	*Minimum Beam Width b*	*Rib Width of Slabs b_w*	*Minimum Thickness of Floors D*	*Column Dimension (b or D)*			*Minimum Wall Thickness*		
				Fully Exposed	50% Exposed	One Face Exposed	$p<0.4\%$	$0.4\%\leq p\leq 1\%$	$p>1\%$
	mm	mm	mm	mm	mm	mm	mm	mm	mm
0.5	200	125	75	150	125	100	150	100	100
1	200	125	95	200	160	120	150	120	100
1.5	200	125	110	250	200	140	175	140	100
2	200	125	125	300	200	160	–	160	100
3	240	150	150	400	300	200	–	200	150
4	280	175	170	450	350	240	–	240	180

NOTES

1 These minimum dimensions relate specifically to the covers given in Table 16A.

2 p is the percentage of steel reinforcement.

FIG. 1 MINIMUM DIMENSIONS OF REINFORCED CONCRETE MEMBERS FOR FIRE RESISTANCE

EFFECTIVE SPAN

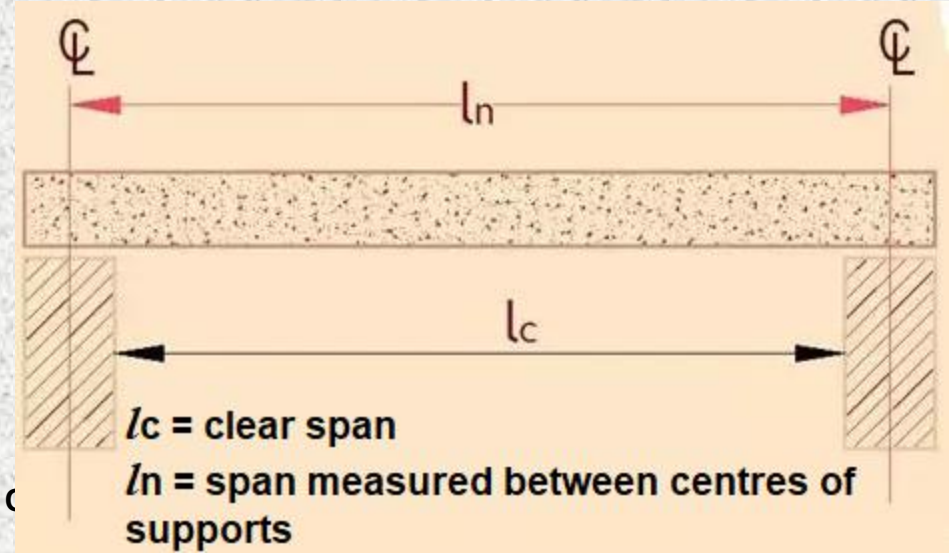
Cl. 22.2 of IS456 (Page 34)

= clear span + d

= span of beam measured between centers of supports

} whichever is minimum **(For simply supported beam)**

= clear span + (d/2) **(For Cantilever Beams)**



NOMINAL COVER TO REINFORCEMENT

Cl.26.4, Table 16 & Table16A of IS456 (Page 46,47)

Table 16 Nominal Cover to Meet Durability Requirements

(*Clause* 26.4.2)

Exposure	Nominal Concrete Cover in mm not Less Than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

NOTES

1 For main reinforcement up to 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.

2 Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by $+10^{\ }_{0}$ mm

3 For exposure condition 'severe' and 'very severe', reduction of 5 mm may be made, where concrete grade is M35 and above.

NOMINAL COVER TO REINFORCEMENT

Cl.26.4, Table 16 & Table16A of IS456 (Page 46,47)

Table 16A

Nominal Cover to Meet Specified Period of Fire Resistance

(*Clauses* 21.4 *and* 26.4.3 and *Fig.* 1)

Fire Resistance	Nominal Cover						
	Beams		Slabs		Ribs		Columns
	Simply supported	Continuous	Simply supported	Continuous	Simply supported	Continuous	
h	mm	mm	mm	mm	mm	mm	mm
0.5	20	20	20	20	20	20	40
1	20	20	20	20	20	20	40
1.5	20	20	25	20	35	20	40
2	40	30	35	25	45	35	40
3	60	40	45	35	55	45	40
4	70	50	55	45	65	55	40

NOTES

1 The nominal covers given relate specifically to the minimum member dimensions given in Fig. 1.

2 Cases that lie below the bold line require attention to the additional measures necessary to reduce the risks of spalling (*see* **21.3.1**).

NOMINAL COVER TO REINFORCEMENT

Cl.26.4, Table 16 & Table16A of IS456 (Page 46,47)

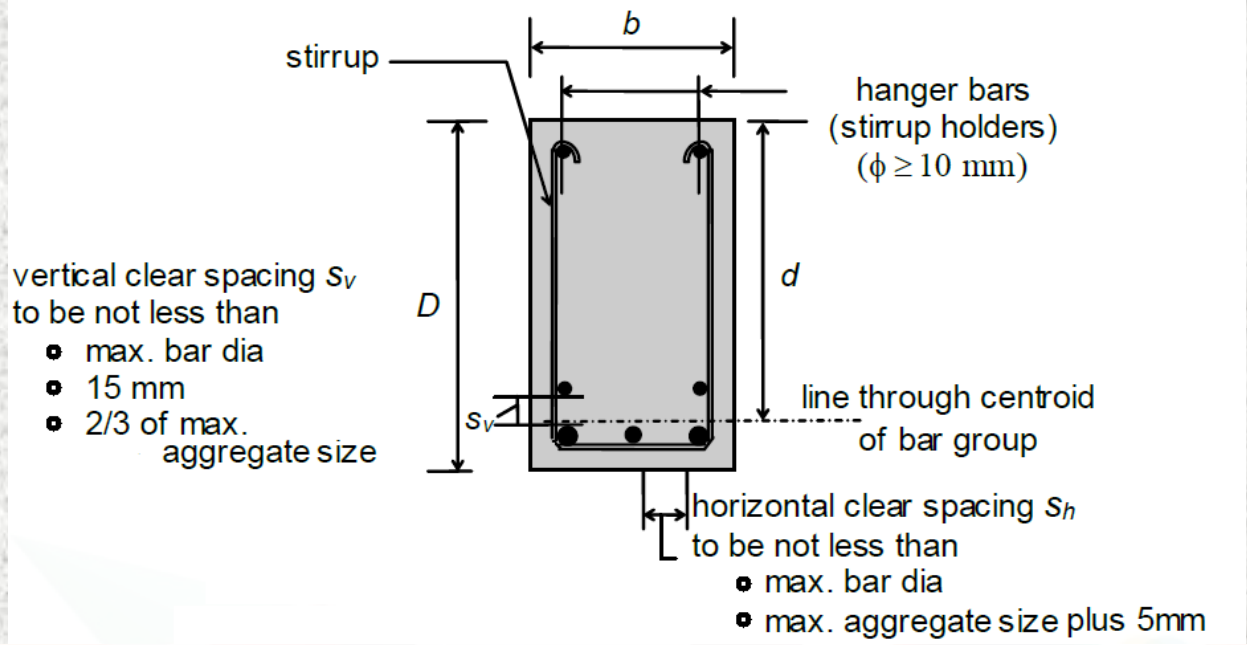
–Minimum clear cover requirements

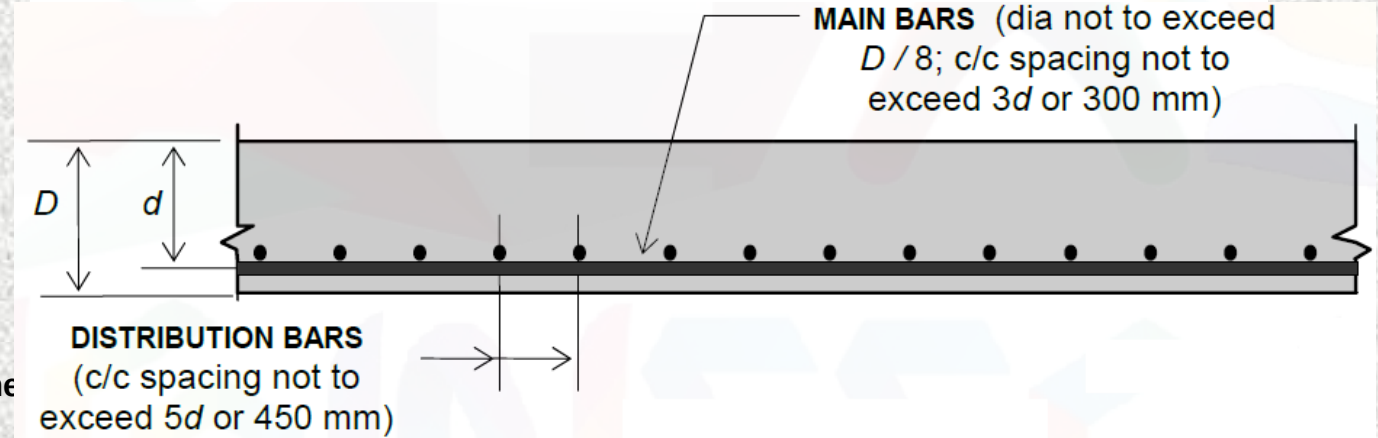
- for columns = 40 mm
- for footings = 50 mm

SPACING OF BARS

Cl.26.3 of IS456 (Page 45)

- Both minimum & maximum limits of spacing between steel bars are specified in code:
  - Minimum Limits => ensure that concrete can be placed easily between bars
  - Maximum Limits => ensure that concrete crack-widths get controlled and bond between concrete & steel is improved.
- Codal provisions are summarized in the following figure:


b
stirrup
hanger bars
(stirrup holders)
(ϕ ≥ 10 mm)
vertical clear spacing s_v
to be not less than
max. bar dia
15 mm
2/3 of max.
aggregate size
D
d
s_v
line through centroid
of bar group
horizontal clear spacing s_h
to be not less than
max. bar dia
max. aggregate size plus 5mm


MAIN BARS (dia not to exceed
D / 8; c/c spacing not to
exceed 3d or 300 mm)
D
d
DISTRIBUTION BARS
(c/c spacing not to
exceed 5d or 450 mm)

AREA REQUIREMENTS OF REBARS

Cl.26.5 of IS456 (Page 46)

- Both minimum & maximum limits of area of steel bars are specified in code:
  - Minimum Limits => helps control cracking in concrete due to shrinkage & temperature change
  - Maximum Limits => helps avoid congestion so that concrete can be placed easily between bars
- Minimum tension reinforcement in beams ($A_{st,min}$)
  - $A_{st,min} = \frac{0.85\ bd}{f_y}$
- Minimum compression reinforcement in beams ($A_{sc,min}$)
  - $A_{sc,min} = 0$
- Minimum flexural reinforcement in slabs ($A_{st,min}$)
  - Ast,min = 0.15 % of Ag (for Fe250)
  - Ast,min = 0.12 % of Ag (for Fe415)

Where Ag is the gross area of section = b x D

Note: Even the distribution bars of one-way slab to be provided this minimum steel.

- Maximum tension & compression reinforcement in beams
  - $A_{st,max}$ = 0.04 bD
  - $A_{sc,max}$ = 0.04 bD
- Side Face Reinforcement
  - To be provided if the depth of the beam (or depth of web) exceeds 750mm
- Helps control cracking in concrete due to shrinkage & temperature change
  - Helps improve resistance against lateral buckling of web
  - Provide a minimum of 0.1% of A_g, where A_g is the gross area of section (or web area), to be distributed equally on two faces
  - Spacing between bars should be ≤ 300mm or beam width (or web thickness), whichever is minimum.

DEFLECTION CONTROL BY LIMITING SPAN-TO-DEPTH RATIO

Cl.23.2 of IS456 (Page 37)

- Deflection control is a serviceability criterion.
- Deflection in structures is limited as follows:

(Including effects of creep, shrinkage & temperature)

- Final deflection due to all loads should be ≤ $\frac{\text{span}}{250}$

(Including effects of creep, shrinkage & temperature)

- But, Deflection due to all loads should be restricted to
  - ≤ $\frac{\text{span}}{350}$ or **20mm**, whichever is less

  (inorder to prevent damages to partitions & finishes)

- Since vertical deflection of structures is a function of the ratio , $\left[\frac{\text{effective span (l)}}{\text{effective depth (d)}}\right]$
  - deflection control is ensured by limiting the (l/d) ratio.

- Deflection criteria is satisfied if the (l/d) ratio is
  - upto 10m spans **(in beams & one-way slabs)**
    - ≤ 7 (for Cantilever)
    - ≤ 20 (for Simply supported)
    - ≤ 26 (for Continuous)
- Above values of (l/d) ratio shall be modified in accordance with the code, depending on the following factors: [Refer Cl. 23.2.1 (b) to (e)]
  - If span > 10m
  - Area & stress in tension reinforcement
  - Area of compression reinforcement
  - For flanged beams